MARINDUQUE

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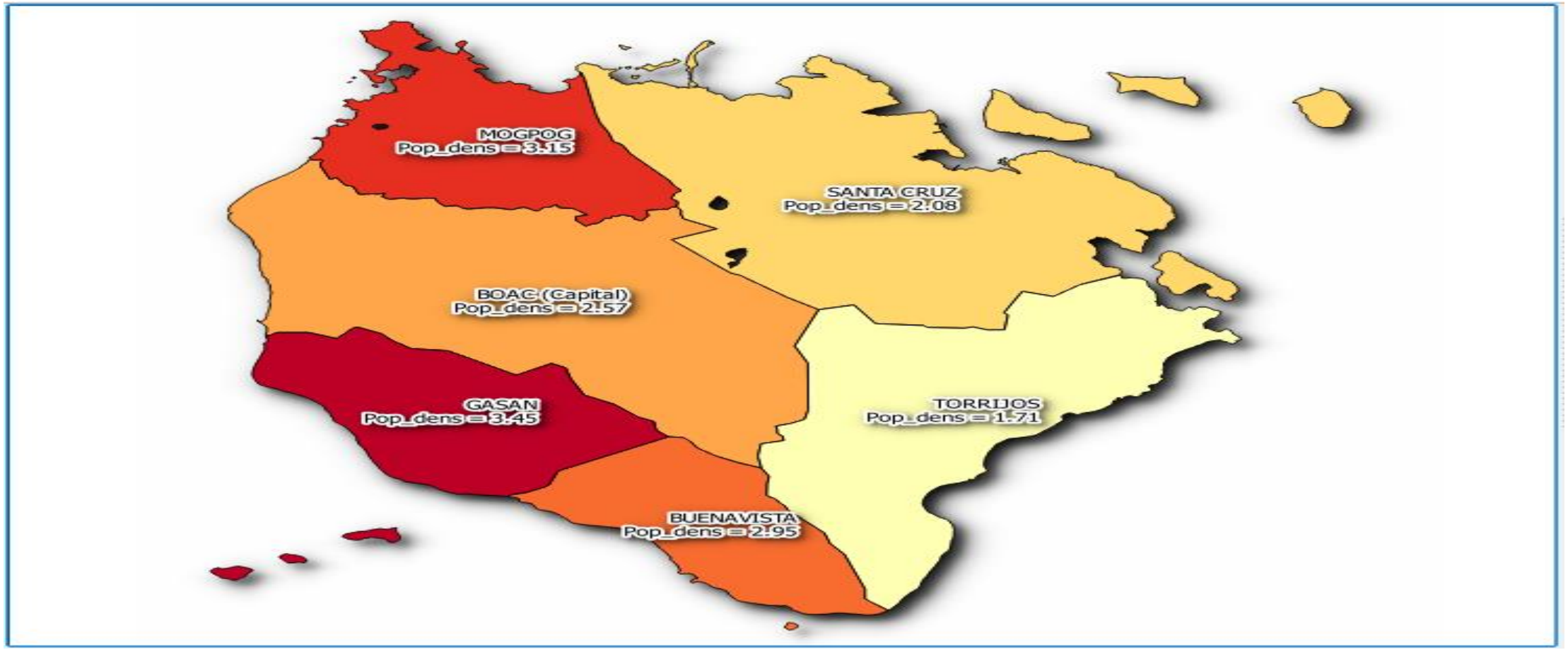
Location [1].

- island province in the Philippines located in Southwestern Tagalog Region or MIMAROPA
- Its capital is the municipality of Boac

http://umich.edu/~snre492/Jones/marcopper.htm

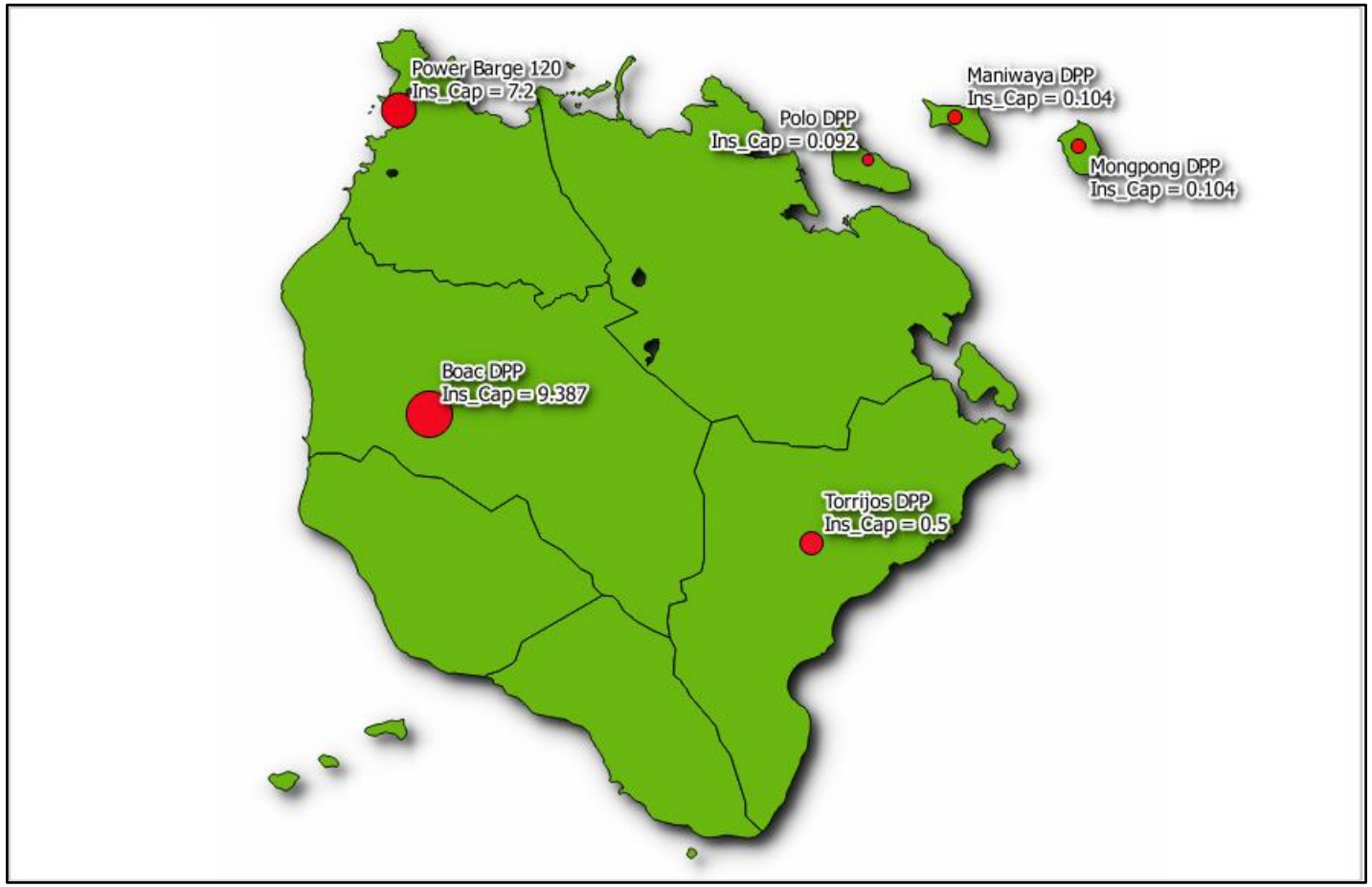
Marinduque's Population Density



Municipalities [4]

MUNICIPALITY	POPULATION	LAND AREA	
BOAC(CAPITAL)	54730	212.70 sq. km	
BUENAVISTA	23988	81.25 sq. km	
GASAN	34828	100.88 sq.km	
MOGPOG	34043	108.06 sq. km	
SANTA CRUZ	56408	270.77 sq. km	
TORRIJOS	30524	178.92 sq. km	

Existing Power plants in Marinduque



Record

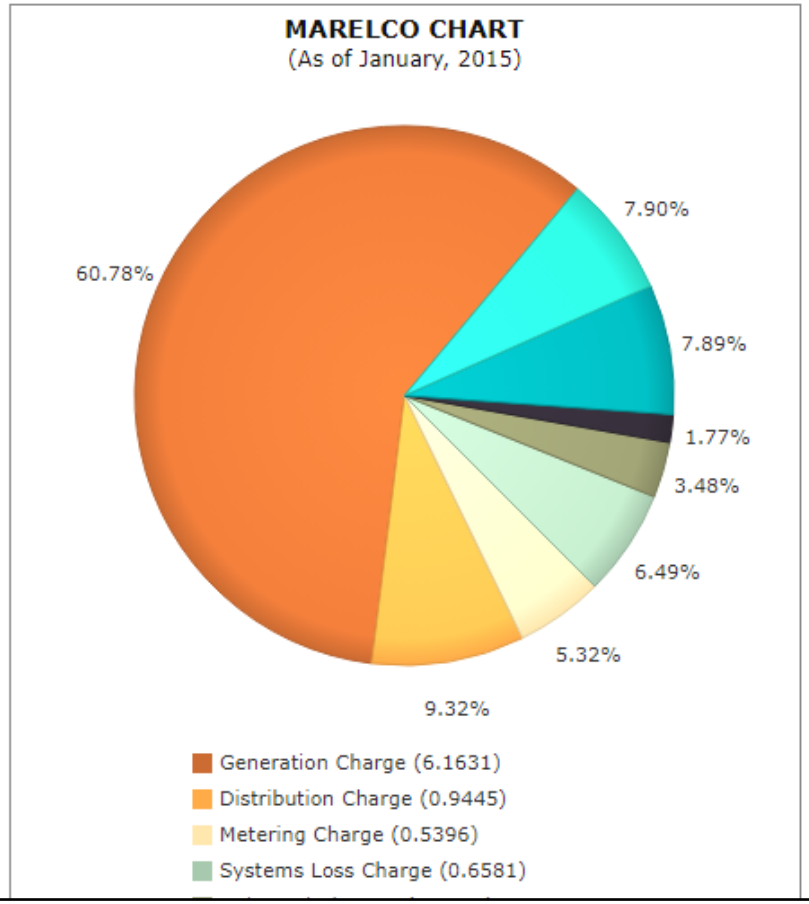
POWER PLANT	OPERATING HOURS	RATED	DEPLOYED	ANNUAL GENERATION	ACF	FUEL TYPE
BOAC DPP	24 HOURS	3.672 MW	3 MW	26280 MWh	49 %	DIESEL
MONARK EQUIPMENT CORPORATION	BACK UP	5.715 MW	4 MW			DIESEL
TORRIJOS DPP	BACK UP	0.5 MW	0.46 MW			DIESEL
POWER BARGE 120	24 HOURS	7.2 MW	4.6 MW	40296 MWh	52%	DIESEL
MANIWAYA DPP	8 HOURS	0.104 MW	0.098 MW	286.16 MWh	31.41 %	DIESEL
MONGPONG DPP	8 HOURS	0.104 MW	0.098 MW	286.16 MWh	31.41 %	DIESEL
POLO DPP	8 HOURS	0.092 MW	0.088 MW	256.96 MWh	31.88 %	DIESEL
TOTAL				**67405.28 MWh**		

GENERATION CHARGE

Php 10.1395/kwh ▼

Effective Rate for Residential Customer

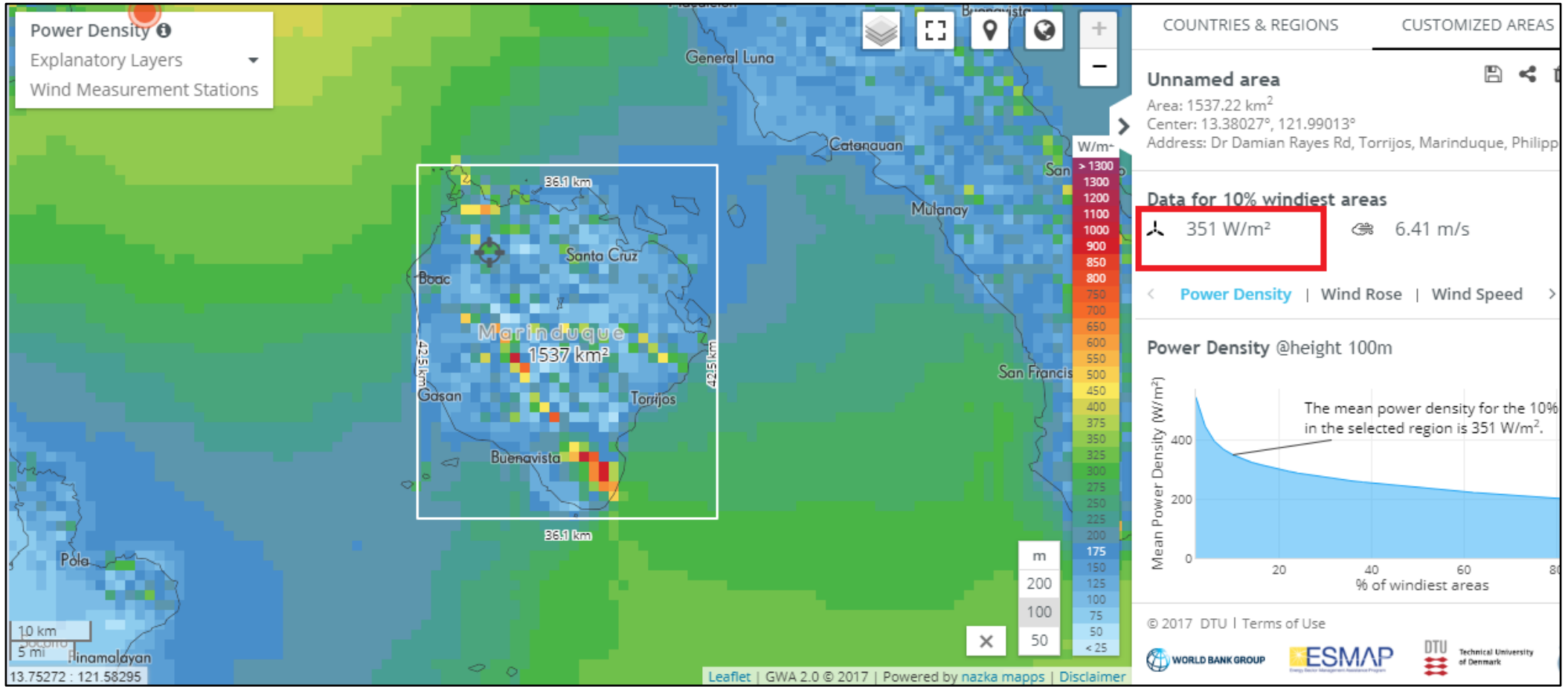
Breakdown of Charges	(Php)
Generation Charge Show Generation Breakdown	6.1631 ▼
Transmission Charge	0.0000 ■
Distribution Charge	0.9445 ■
Metering Charge	0.5396 ■
SystemsLoss Charge	0.6581 ▼
UC-ME	0.1561 ■
UC-EC	0.0025 ■
UC-Stranded Cost	0.1938 ■
LifeLine Rate Subsidy	0.1796 ▲
SeniorCitizen Subsidy	0.0011 ■



Generation Charge is 6.1631 Php / kWh

From http://kuryente.org.ph/electric-company/rates/41

Wind Energy Assessment via Global Wind Atlas



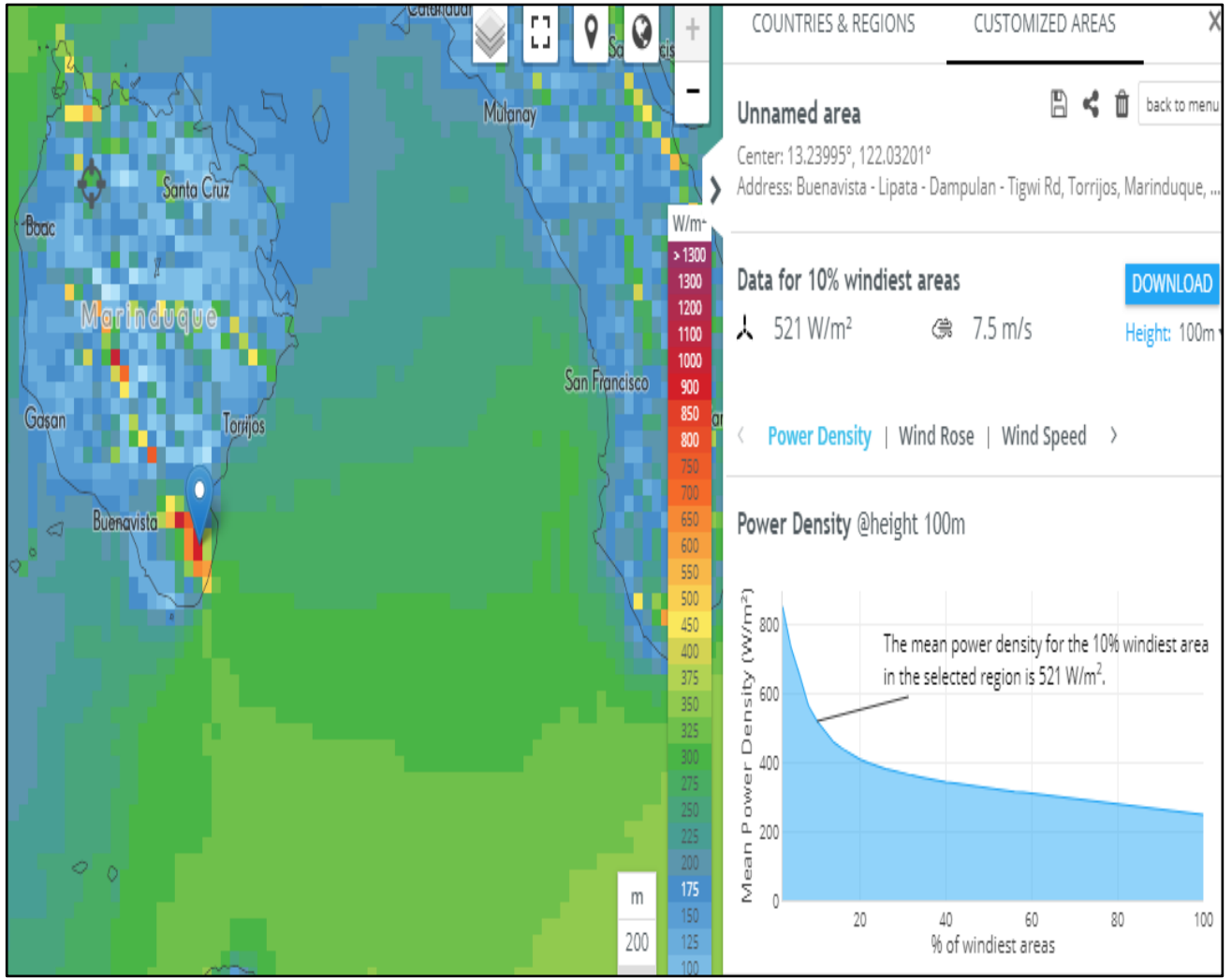
https://globalwindatlas.info/area/Philippines/Region%20I%20(Ilocos%20region)

The Whole Region

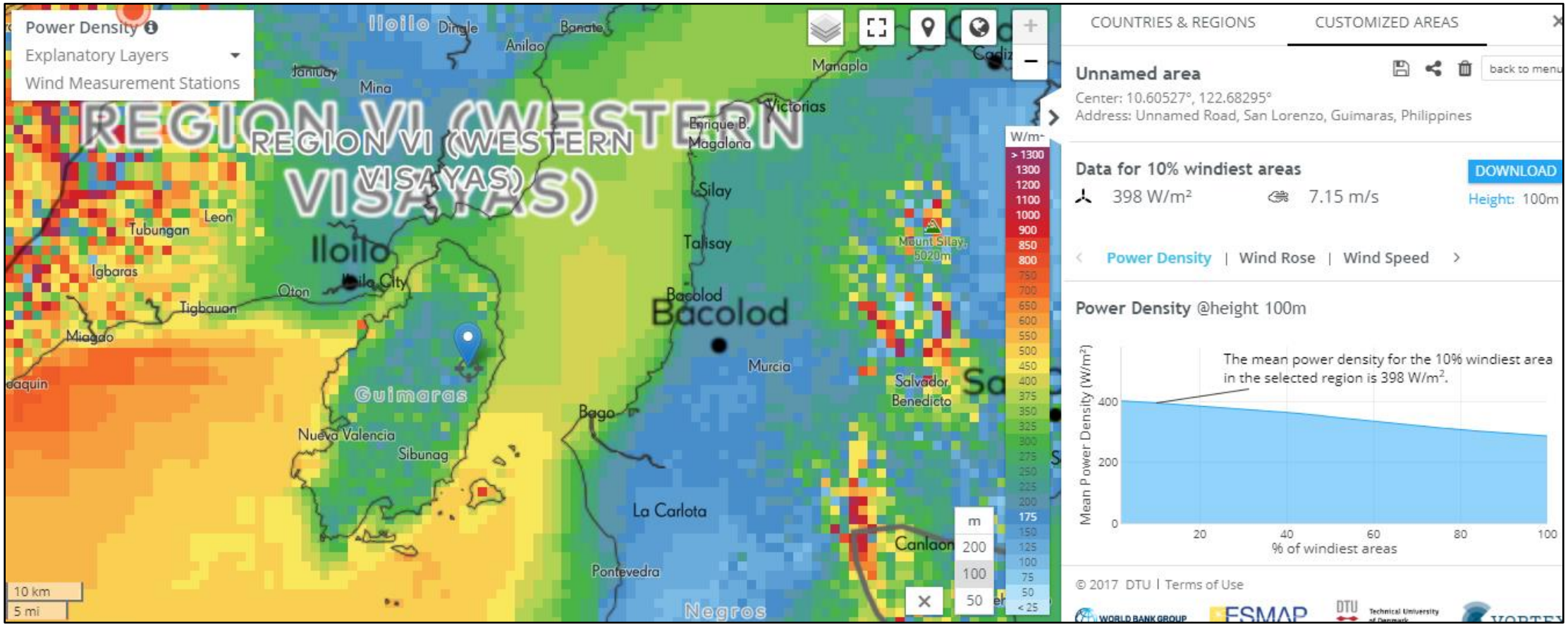
- at 100m elevation, 10% windiest area in the region tallies 351 watts per square meter mean power density
- just by looking at the legend shown in the GUI and observing at the region, the power per square meter of almost the whole region is not that high, but

Point Clicking on the “Redest” Portion

After point clicking on the “redest” portion of the region which is at Buenavista, Marinduque, it will give us a relatively larger mean power density of 521 watts per square meter, this is at 100 m elevation

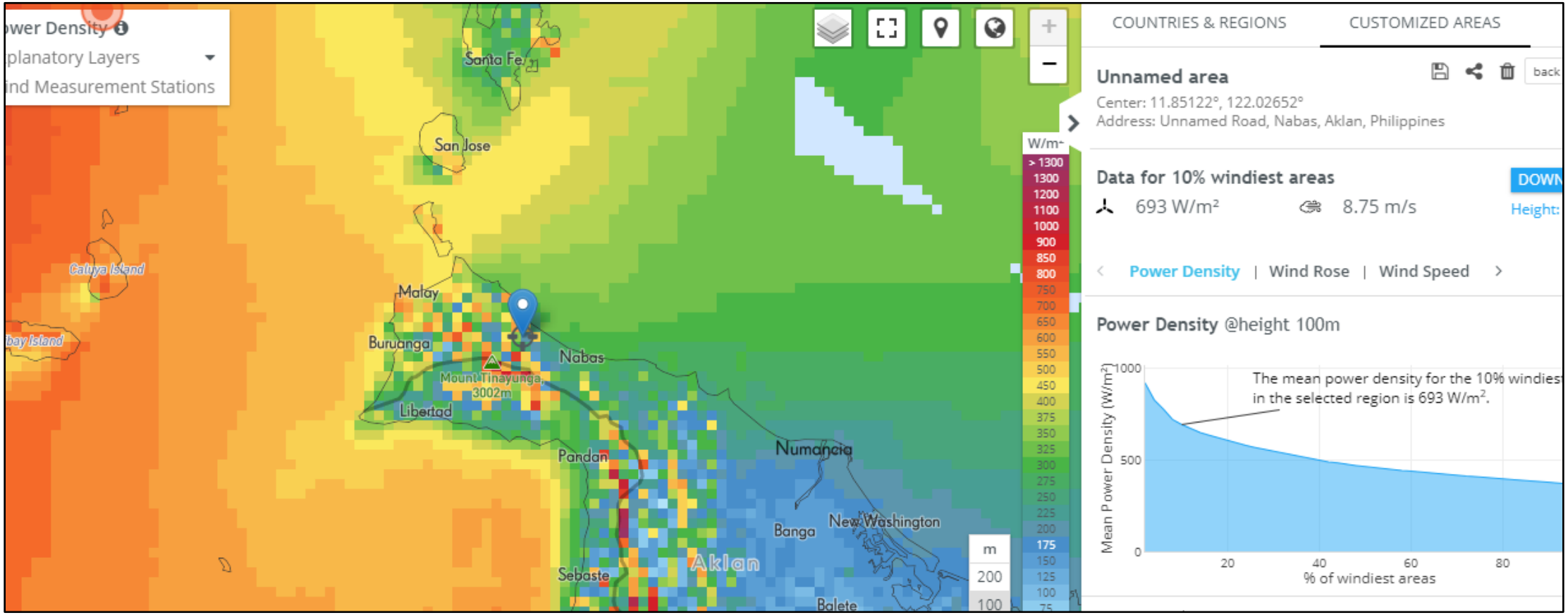


Let us compare it to San Lorenzo, Guimaras



- San Lorenzo, Guimaras is the location of one of Philippines' wind energy farm, the San Lorenzo Wind Farm (50 MW installed capacity)
- San Lorenzo has a mean power density of 398 watts per square meter
- The recorded mean power density of Marinduque is relatively larger than the mean power density of San Lorenzo

Nabas, Aklan Comparison

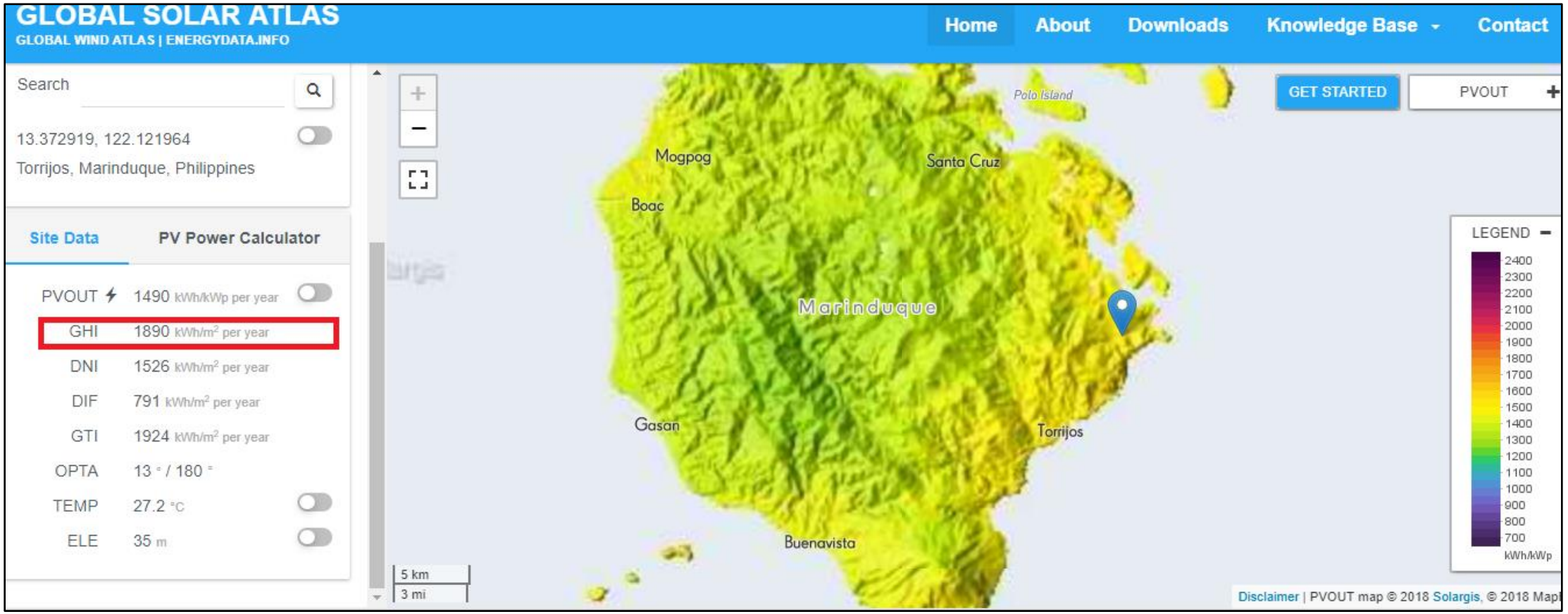


- 36 MW wind energy source is located in Nabas, Aklan
- Mean power density due to wind in Nabas, Aklan is relatively larger than of Marinduque’s but it does not have that much of a difference

Implication

- Marinduque’s potential for wind energy source is noticeable
- Proposing a wind energy farm in Buenavista, Aklan is reasonable for it has the biggest mean power density across the region of Marinduque
- Marinduque’s potential for wind energy source is complemented by its large land area, Buenavista has a land area of 81.25 sq. kilometer and according to [6], “a 2-megawatt wind turbine would require a total area of about half a square kilometer”, making it even more possible to build a wind energy farm in Buenavista, Marinduque

Solar Assessment via Global Solar Atlas



Implication

- It is observable in the GUI of Global Solar Atlas that Torrijos, Marinduque has the largest Global Horizontal Irradiance across the Marinduque region, it has a high potential for solar energy having a GHI of 1886 kWh per square meter.
- Also, it is favourable that Torrijos would be the place for the solar farm because the municipality has the least population density of only 170 persons/sq.km [4] and having a very large land area of 178.92 sq. km [4]

Buenavista, Marinduque Wind Data (m/s)

Lat 13.248 Lon 121.981	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
10-year Average	6.59	5.69	5.28	4.17	3.36	4.48	4.26	5.55	4.24	4.55	5.96	7.00

This is a 10 year average wind data from NASA's free access database.

Link: *https://eosweb.larc.nasa.gov/cgi-bin/sse/grid.cgi?email=skip@larc.nasa.gov*

Torrijos, Marinduque Horizontal Insolation (kWh/m^2/day)

Lat 13.334 Lon 122.016	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
22-year Average	4.34	5.09	5.84	6.53	6.18	5.32	4.99	5.11	4.93	4.51	4.12	3.87

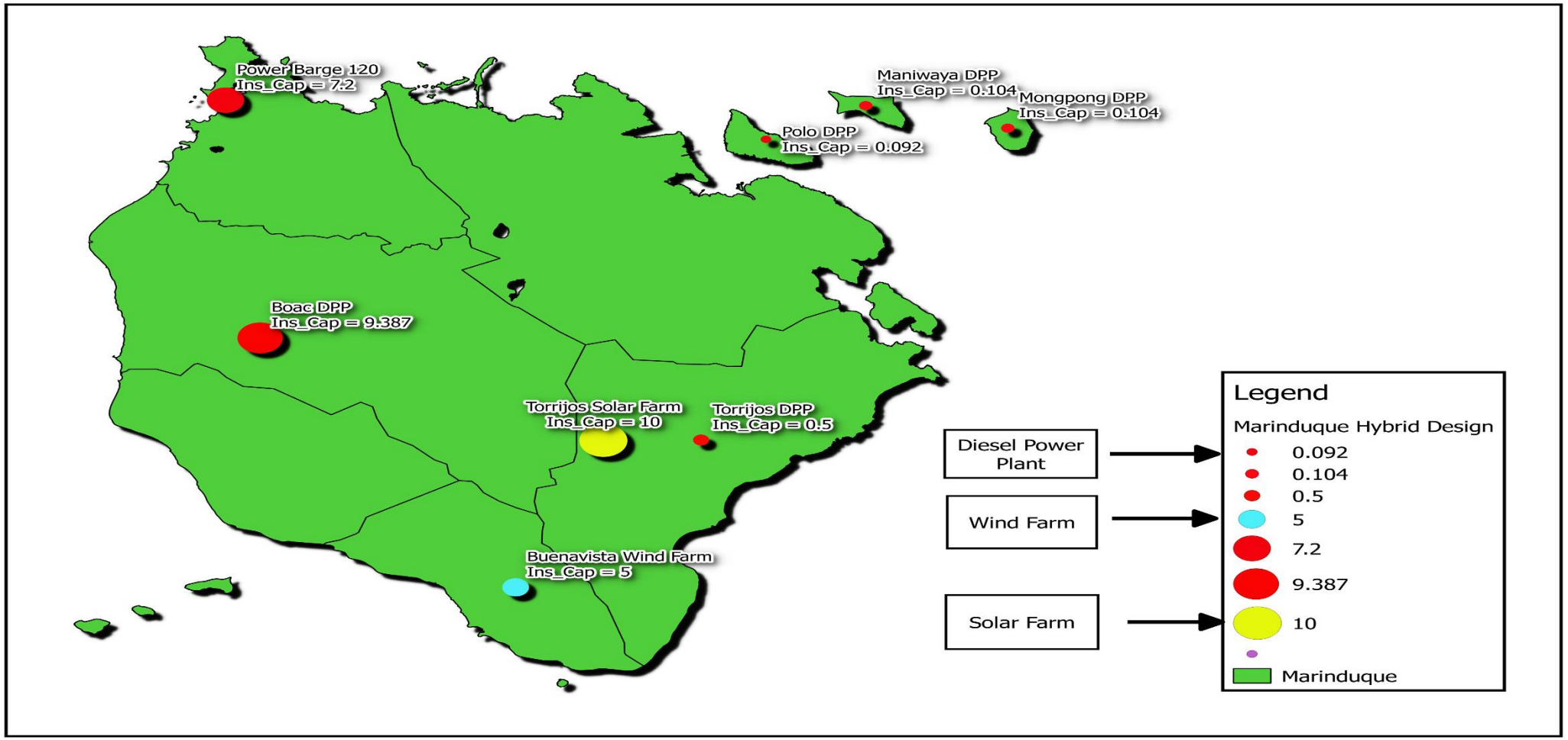
This is a 22 year average of horizontal insolation data from NASA's free access database.

Link: *https://eosweb.larc.nasa.gov/cgi-bin/sse/grid.cgi?email=skip@larc.nasa.gov*

Hybrid System Design

- Design a Hybrid System that can supply the island’s energy needs
- Hybrid system composed of wind and solar renewable energy sources and the existing diesel power plants
- Consider limiting the carbon emission in designing
- HOMER is employed to design an optimized hybrid system

Map of proposed RE's along with existing DPP's



Carbon Emission and LCOE from existing DPP's solved in HOMER

System architecture

Boac DPP	3,000 kW
Power Barge120	4,600 kW
Torrijos DPP	460 kW
Polo DPP	88 kW
Maniwaya DPP	50 kW
Mongpong DPP	98 kW
Monark Equiment	4,000 kW

Cost summary

Total net present cost	$ 438,678,816
Levelized cost of energy	$ 0.417/kWh
Operating cost	$ 26,900,056/yr

Emissions

Pollutant	Emissions (kg/yr)
Carbon dioxide	60,432,392
Carbon monoxide	149,169
Unburned hydocarbons	16,523
Particulate matter	11,245
Sulfur dioxide	121,359
Nitrogen oxides	1,331,045

Specifications of Components

COMPONENTS	CAPACITY
BOAC DPP	3000 kw
MONARK EQUIPMENT CORPORATION	4000 kw
TORRIJOS DPP	460 kw
POWER BARGE 120	4600 kw
MANIWAYA DPP	50 kw
MONGPONG DPP	98 kw
POLO DPP	88 kw
PV ARRAY	20000,25000,30000 kw
WIND TURBINE (WES 30)	250 kw AC
BATTERY (300 Trojan L16P)	2.16 kwh
CONVERTER	15000 kwh

Proposed Setup (HOMER Optimized)

System architecture

PV Array	30,000 kW
Wind turbine	40 WES 30
Boac DPP	3,000 kW
Power Barge120	4,600 kW
Torrijos DPP	460 kW
Polo DPP	88 kW
Maniwaya DPP	50 kW
Mongpong DPP	98 kW
Monark Equiment	4,000 kW
Battery	1,500 Trojan L16P
Inverter	15,000 kW
Rectifier	15,000 kW
Dispatch strategy	Cycle Charging

Cost summary

Total net present cost	$ 360,420,000
Levelized cost of energy	$ 0.343/kWh
Operating cost	$ 17,713,774/yr

Emissions

Pollutant	Emissions (kg/yr)
Carbon dioxide	31,862,958
Carbon monoxide	78,649
Unburned hydocarbons	8,712
Particulate matter	5,929
Sulfur dioxide	63,986
Nitrogen oxides	701,793

Electrical

Component	Production (kWh/yr)	Fraction
PV array	44,352,912	46%
Wind turbines	16,058,743	17%
Boac DPP	11,990,222	13%
Power Barge120	9,628,506	10%
Torrijos DPP	668,374	1%
Polo DPP	94,541	0%
Maniwaya DPP	52,122	0%
Mongpong DPP	68,890	0%
Monark Equiment	12,656,629	13%
Total	95,570,944	100%

Discussions

The results from HOMER which are presented shows that the optimized hybrid system is composed of generally a 30 MW solar energy source and a 10 MW wind energy source, it is observable that it limits the usage of existing diesel power plants to only 37 % of the total energy consumption of the island, resulting in a lesser carbon emission which is about a half of the total carbon emission of the existing diesel power plants in the island, and surprisingly, the levelized cost of energy became lesser with the proposed hybrid system, from $ 0.417 to $0.343.

Conclusion(s)

- Practicing the use of Renewable Energy is of big help in addressing problems related to CO_2 emission
- The island of Marinduque has a high potential for solar and wind energy

References

1 - https://en.wikipedia.org/wiki/Marinduque

2 - http://newsinfo.inquirer.net/926591/diesel-fired-plant-boosts-marinduque-power-supply

3 - https://deepresource.wordpress.com/2012/04/23/energy-related-conversion-factors/

4 - Census of Population (2015). Highlights of the Philippine Population 2015 Census of Population. PSA. Retrieved 20 June 2016.

5- https://carbonpositivelife.com/co2-per-litre-diesel/

6- https://sciencing.com/much-land-needed-wind-turbines-12304634.html